ENVIRONMENTAL VALUATION AND ITS IMPLICATIONS ON THE COSTS AND BENEFITS OF A HYDROELECTRIC PROJECT IN KERALA, INDIA

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ABSTRACT

Although significant developments have taken place in the area of valuation of the environment, the gap between theoretical principles and their operationalisation still remains. This paper makes an attempt to contribute towards bridging this gap. It explores the ways of 'doing' environmental valuation in practice in the specific context of a proposed hydroelectric project. Valuation is done within the overall framework of cost-benefit analysis. In the process, a number of methodological issues in environmental cost-benefit analysis have been dealt with.

JEL Classification : H 43

Key words: Hydroelectric project, environment, valuation, discount rate, social costs and benefits

1. Introduction

It is now being increasingly recognised in developing countries that environmental effects of development projects must be properly assessed and incorporated into the formal project analysis. Most international aid agencies and national governments now require some form of ex-ante economic appraisal of environmental aspects of planned projects. This paper is based on the results of such an evaluation exercise actually carried out by the authors on the advice of an expert committee appointed by the Government of India to examine the desirability of a hydroelectric project in the state of Kerala in India. Although in recent years significant developments have taken place in the area of valuation of the environment, the gap between theoretical principles and their operationalisation still remains significant. This paper makes a modest attempt to bridge this gap. The paper explores the ways of 'doing' environmental valuation in practice in the specific context of a proposed hydroelectric project.

It is generally believed that hydropower projects substitute a high carbon source of fuel with cleaner energy. Even if it is true, it has to be grounded on an explicit cost-benefit analysis of alternative possibilities. One can therefore think of at least two immediate alternatives to be compared with the proposed project: (1) rejecting the project and not having the benefit of additional electricity, and (2) generating the same quantity of electricity by an alternative project (e.g. thermal power plant).

Thus, in principle at least, it gives us an opportunity to explore a methodological approach that goes beyond ‘accept’ ‘reject’ kind of conclusion. In most cases of project appraisal, only one single project idea is presented, thereby limiting unnecessarily the number of alternatives considered. However, data limitations and other constraints may restrict our ability to fully capture all the costs and benefits involved.

Section 2 briefly provides the background. Section 3 deals with the methodological issues in environmental valuation and cost-benefit analysis. In section 4, first, the costs and benefits in the specific context of the hydroelectric project are presented in detail, and then the feasibility of the project under various assumptions are discussed. Section 5 concludes.

2. The background

The Kerala State Electricity Board (KSEB) has planned to set up a hydroelectric project that includes construction of a dam in the Puyankutty tributary of Periyar river and generation of electricity with an installed capacity of 240 MW. The proximate effects of the project are likely to be submergence of about 2800 hectares of tropical forests, two tribal settlements and stretches of cultivated land of non-tribal settlers. The forests that will be submerged sustain timber, minor forest products, diverse flora and fauna, and other materials such as reed – a raw material used by traditional artisans and newsprint companies. Besides electricity, the other benefits envisaged are development of irrigation and infrastructure such as roads in areas adjacent to the project area. The storage of water in the reservoir is also expected to enhance availability of water in the downstream of the Periyar river during summer.

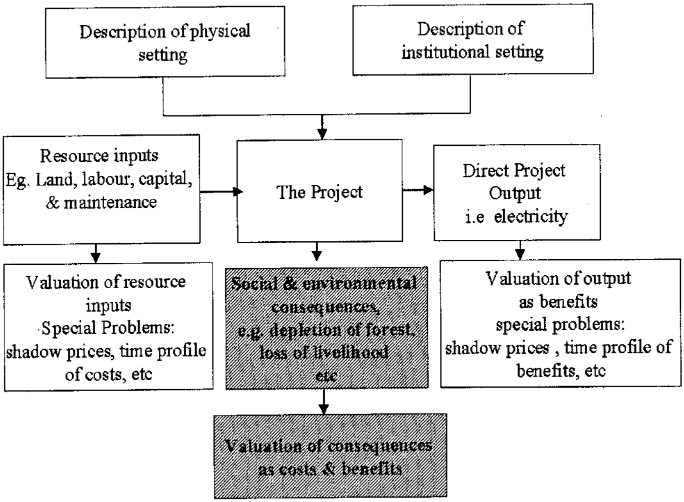
Submergence of forest land and dislocation of human settlements, which the proposed project will lead to, predictably caused concern for their both social and environmental consequences. To assess the impacts two studies were made – one of social losses (due to dislocation of human population and loss of forest-based materials) and the other of the environmental impact (due to the loss of flora and fauna and associated biodiversity). It was subsequently felt that an overall cost-benefit analysis should also be done, using information generated by these two separate 'impact assessment' studies. And the experience of this last study, which we have just completed, forms the background of the paper.

3. From impact assessment to cost-benefit analysis: methodological issues

3.1 The basic principle

The basic methodology of project appraisal suggests that first the social and environmental impacts are to be identified and measured, and then, the second step would be to translate them into monetary terms for inclusion in the cost-benefit analysis of the project. The principle that underlies such an approach is that the resource allocation process must be such that all the effects are 'internalised'. In other words, resource allocation will be efficient if all the effects — negative and positive, direct and indirect, tangible and intangible — are included in the analysis. For development projects, this means that such effects need to be incorporated as costs or benefits in the analysis that goes into the process of decision making on the project. In this sense, it is an attempt to broaden the scope of conventional social cost-benefit analysis. A schematic representation such as figure 1 may be useful to understand how valuation of environmental costs and benefits enter into the social cost-benefit analysis. The conventional social cost-benefit analysis would include all those boxes except the shaded ones. Any extension of this framework to include the environmental effects would require quantification of the environmental effect and their valuation.

Figure 1:



Thus the 'net present value (NPV)' or 'internal rate of return' criteria adopted for such analysis is extended to include environmental costs. As suggested by Weiss (1994), it can be presented as:

$$NPV = PV\ (B-C+E)$$

where PV is present value at a discount rate r using the discount factor $1/(1+r)^t$, for year t; B is the direct benefits from the project and C is the direct costs; E is the net environmental effect (Weiss, 1994:3). It may be noted that some environmental effects can be negative and others positive. The negative effects are obvious, and an example of positive environmental effect of a hydroelectric project is availability of more water downstream of the river because of the potential summer-discharge from the reservoir. Net environmental costs E in present value terms 'should be interpreted as a sum which when invested at a rate r will grow over time so that it will be sufficiently large to just compensate sufferers from future environmental external effects' (Weiss, 1994:3). This procedure is grounded on the potential compensation criteria whereby projects are evaluated on the basis of their ability to generate income to achieve potential compensation, but not much concerned about whether compensation is actually paid out or on the mechanisms of compensation. There are arguments (for example, Norman and Dixit, 1990) for using the avenues of compensation in general, and the need for compensating projects for the sustenance of natural capital (Markandya and Pearce, 1994). We initially carry out the cost-benefit analysis with the potential compensation criterion, and then discuss the issues of compensating projects and compensation to losers. There were also criticisms of the cost-benefit approach mainly due to the problems of quantifying and monetising all the environmental effects. In order to overcome this problem multi-criteria analyses have been attempted by some analysts (Chopra, 1998; Munda et al, 1994). However, we have attempted evaluation of the environmental impacts within the cost-benefit framework so as to make it compatible with the existing decision making processes with regard to such development projects in countries like India. This has been done while keeping in mind the difficulties in accurately estimating some of the environmental gains and losses.

Although it is difficult to determine the 'optimum stock of resources' from sustainability standpoint, it is often noted that in a great many less developed countries stocks are well below what might be considered as optimum. It follows, then, that for these economies, any project that reduces the stock of resources must be accompanied by some compensating project elsewhere. We take this into consideration and estimate various compensating expenditures that should be included in the total cost of the project. The environmental impact assessment study made by a scientific research organization (Salim Ali Centre for Ornithology and Natural History, SACON for short), however, argues for preservation of the whole forest area. In other words, the belief that underlies their study is that no finite amount is adequate for compensating the loss of the forest. Non-economists often show sympathy towards this view. Arguments for preservation may come from essentially two different positions. One might assume that 'non-use values' of a natural environment are prohibitively high, so that the benefits of preservation always outweigh the costs. In this view, people derive benefits from the mere existence of the environment even though they make no use of it. This is clearly different from the view that non-human species are intrinsically valuable, independent of any use they may have to humans (Callicott, 1986). While the former is still a utilitarian view in the sense that the resources, although not used, have value in relation to human welfare, the latter is clearly non-utilitarian (Fisher and Hanemann, 1997). Cost-benefit analysis, however, examines the question of preservation in the light of general objectives of national policy. As pointed out by the classic UNIDO Guidelines, the main rationale for conducting social cost-benefit analysis is "to subject project choice to a consistent set of general objectives of national policy". We argue that even though perceptions of national policy objectives in developing countries have changed, there is no reason to believe that preservation of the biotic status quo is what is revealed to be the preferred choice by the society. In the discussions on costs and benefits of development projects, arguments range from one polar position to another. While earlier approaches towards project appraisal largely ignored environmental effects, popular opinion in recent times often tends to move to the other extreme. In economists' language, if earlier analysts assumed zero social cost for the environmental damage, arguments for preservation of any piece of natural environment without explicit valuation amount to assigning infinite value to the environmental resources. For decision making, it can be argued, valuing environmental resources at infinity is not a great advance over valuing them at zero.

3.2 Identification and valuation of items of value

In the theoretical literature the total economic value of the environment is divided into use and non-use values (Fisher and Hanemann, 1997; Dixon and Lal, 1997). The use value includes not only those arising from its use in production and/or consumption, but also the option value - which takes into account the possibility of its future use based on future information. Even if a resource is neither used currently nor considered usable with the current level of information, its option value may be positive and significant. The potential for finding a useful wild gene or plant for pharmaceutical purposes in future from a forest can have a value today, (with discounts for uncertainty), and this can be taken as an example of option value. Then there are non-use values, such as 'existence value, which non-users may be willing to pay for the preservation of the environmental even if it is not used either today or in future.

Even though the concept of use value is the most straightforward, a number of problems have to be addressed in the operational context. To estimate costs due to submergence of forest land, various goods and services (including ecological services) are considered. They include timber and other products such as reed; erosion control, water retention, effects on the global carbon flux, and so on. For various categories of ecological services we draw on existing studies and make necessary adjustments. As far as 'non-use values' are concerned, the direct methods such as willingness-to-pay surveys to estimate existence value were considered to be rather infeasible, given the costs and benefits of such methods. Instead, we carry out a sensitivity analysis with alternative specifications of non-use values.

3.3 Measurement of environmental values

Some of the direct use values might get reflected in market prices, while a major part of the goods and services produced by the environmental resources require shadow pricing and other indirect methods of measurement. In the cases of goods and services for which markets do not exist, Contingent Valuation Method (CVM) is sometimes used to determine consumers' preferences by constructing hypothetical markets. This is supposed to provide estimates of willingness to pay for the expected benefits or willingness to accept compensation for foregone benefits.

In a specific empirical situation, some methods may prove to be more appropriate than others. The choice is largely guided by 'cost-benefit' considerations. The costs of data collection and various difficulties on both conceptual and practical sides make certain methods less attractive. CVM involves more of these difficulties in the specific context of the project. Considering the amounts of effort and resources required to conduct such a valuation in an acceptable and scientific manner, and also by considering the benefits of doing so, we decided not to use this method. Instead, we have followed methods based on market and non-market information. In doing so we have drawn on a number of studies on environmental valuation carried out in recent times on various eco-systems such as watersheds, wet lands and tropical forests (for a review, see Dixon and Lal, 1997; Dixon, 1997, Winpenny, 1991).

Even though direct use values are fairly straightforward in concept, they are not easy to measure in most cases. Measuring the value of medicinal plants, for example, may be extremely difficult. Market prices, wherever they are available and somewhat reflective of the true opportunity costs of resources, have been used. Preventive expenditures required to mitigate a loss, indirect estimates made by other researchers in similar empirical situations in other parts of the world, and so on, are the major tools of valuation employed in this analysis. However, all these will give us only the use-value part of the total economic value. The other component, i.e. the non-use values, can be estimated only through such controversial techniques as CVM. Since we have not attempted it here, efforts have been made to capture non-use values indirectly. A hypothetical amount has been arrived at, which, if quoted by each and every Kerala household as their 'willingness to pay', would give a total value equal to the net benefit of the project (after accounting for the direct cost and the use values of the environmental losses). Such estimation, combined with our intuitive idea about what should be a reasonable range of such imputed values, may provide some insights into the feasibility of the project. Such a method of sensitivity analysis is not uncommon in the literature (for example, see Pearce,1994).

3.4 Choice of the discount rate

In addition to the problem of arriving at estimates of environmental losses and gains, cost-benefit analysis has to tackle the problem of selecting an appropriate discount rate. The choice of discount rate for social cost benefit analysis in general and for the incorporation of environmental issues in particular has been a topic of extensive debate in economics.

Applying positive discount rates appears to work against the interests of future generations if project choice biases benefits in favour of current periods and place social costs in future periods. Thus, there is an argument for using near zero discount rate (Parfit, 1983; Goodin, 1986). However, a number of economists have argued that "there is no unique relationship between high discount rates and environmental deterioration as is often supposed (Markandya and Pearce,1994: 32)". It is also noted by Ayres and Kneese (1969) that the demand for natural resources is generally less with high discount rates than with low ones.

Thus it remains unclear how the choice of discount rate affects future exploitation of environmental resources. The majority opinion within environmental economics is therefore not in favour of adjusting discount rates to accommodate environmental considerations. What has been suggested, instead, is to use other mechanisms to take care of environmental concerns. One such alternative is to incorporate sustainability criteria into cost-benefit analysis in the form of compensating projects so that the net stock of natural capital is not diminished. This and other issues of compensation are discussed in the following section.

3.5 Issues of compensation and compensating project

Although environmental cost-benefit analysis is only concerned with potential compensation (ability to compensate) and not actual compensation made, there are reasons why we should seriously consider possibilities of actual compensation. As noted earlier, the political economy approach has provided arguments for using the existing instruments of income transfer for actual compensation (Norman and Dixit, 1990). The debates on the choice of discount rate have also brought out the importance of mechanisms of actual compensation to future generations (Markandya and Pearce, 1994: 39). Yet another reason to think about compensation is the inequality between the gainers and the losers. If the losers are relatively poor, as in the case of many development projects in the southern world, whether compensation is actually made or not has important implications. We have also taken into account some of these issues in this cost-benefit analysis. Apart from insisting on suitable mechanisms for compensating the losers, mainly the tribal people and traditional artisans who depend on the forest, this concern is also explicitly incorporated in the cost benefit analysis. In the first step of our analysis, we take the narrower definition of benefits and subject the cost-benefit comparison to more stringent criteria in that the issue of compensation dominates the cost side. At this stage total loss to the poorer people can thus be weighed against the overall gains to society in terms of the benefits of power production as other benefits to the overall society are neglected.

Compensation of future generations can be meaningfully approached through a concern for sustainable development, which in turn can be addressed through compensating projects as discussed in the earlier sections. The purpose of such projects is to serve two interests: "the current generation over their life time, and future generations since they inherit no smaller a stock (of natural resource) than their predecessors" (Markandya and Pearce, 1994: 47). For example in the case of a project leading to the destruction of forests, the compensatory programme should aim at afforestation even though all the functions served by a standing forest cannot be immediately (or ever) served by a newly planted forest. Though there are genuine reasons for not designing a compensatory project for each and every development project, the existing regulations in India compelled the planners of the Puyankutty project to come out with a compensatory afforestation programme. This has provided us the scope for analysing this compensation issue within the environmental cost benefit analysis framework. We have attempted a comparison of the forest related environmental losses with the cost of the proposed afforestation programme.

4. From theory to practice

In environmental cost-benefit analysis, there is no straightforward way of applying the box of tools to determine feasibility of a project in an unambiguous manner. However, at each stage in the operational context the analyst has to provide detailed justification so as to help the policymaker to arrive at a decision. The rest of the paper reports this process. In section 4.1 all the conceivable social and environmental losses are identified and valued. Section 4.2 deals with the benefits. And section 4.3 puts together costs and benefits to examine the feasibility of the project under alternative scenario.

4.1. Identification and valuation of the losses in practice

Among the losses due to the proposed project, some have been recognised by the planning agency (KSEB) itself, and a few others were identified by the assessments of social and environmental impacts of the project. However, they leave out quite a few important items which hydro-electric projects located in tropical forest areas typically involve. We discuss here how all these losses are valued in the specific context of the project.

4.1.1. Direct costs in monetary terms

The monetary cost of the project is estimated to be Rs.820 crores as per the latest calculations. The items taken into account for the cost estimation include civil (dam, roads, buildings and communication for the project) and electrical works (power house and transmission), and their establishment costs. In addition, Rs. 56.5 crores (in 1994, approximately 10 percent of the total cost) was earmarked for what is called ‘environmental management’, which includes compensatory afforestation (Rs.32 crores), catchment area treatment (Rs.17.3 crores), rehabilitation (Rs.2.5 crores) and environmental safeguards and monitoring (Rs.4.7 crores). We need to redefine direct monetary costs to suit our framework. If all social and environmental losses are valued and added to the cost side of the project, accounting for the costs of ‘environmental management’ again in the total estimated cost of the project would amount to double counting. The direct cost is to be spent during the whole construction period of the project, which is expected to be 10 years. Accordingly, the expenditure for years between 1 and 9 are converted into PVs at different discount rates.

4.1.2. Loss of forest land

The project results in submergence of 2800 hectares of forest land. First we identify and estimate the values of various goods and services (including the ecological services) that the forest provides. While some of them take the commodity form, for most of the services market does not exist mainly because of the public good nature of the services.

1) *Timber*: It may be reasonable to assume that the Puyankutty forest is a 'normal forest' - a term used in forestry literature to reckon a mature unmanaged forest. This is so because the wet-tropical forests are quicker to mature and there was no significant extraction of trees (other than reeds) from these forests for a long time. Under this assumption, the forest is in a state of equilibrium whereby annual growth of timber is almost equal to annual decay (Pant, 1984:341). Thus there is no net natural addition to the timber stock. Assuming that the relative price of timber does not change in future, the annual loss due to the destruction of timber stock by the project is equal to the interest borne by the financial capital formed by the net revenue of extracting the whole stock of timber at a stretch[1] . Since the interest on the revenue of timber sales is not accounted in the benefit stream, the financial loss due to timber destruction is not considered here as a cost,

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1 There will be net growth of timber if it is extracted and the stock is reduced from the equilibrium level. However, the optimal extraction level is reached when the rate of growth of the value of stock is equal to the discount rate (i.e. Fisherian principle). Thus the flow of income through optimal extraction will be equal to the discount rate.

2) *Minor forest produce (MFP):* The SACON study made a list of some economically important species such as the medicinal plants (other than timber) available in the project area. However, no estimate of the quantum of MFP currently extracted (or potentially extractable) from the submergible area is available. A partial way out of this data problem is to depend on the state-level data on extraction of MFP.

a) *Fuelwood*: The maximum annual collection of fuelwood from the forests of Kerala during the past ten years comes to 82888 metric tonnes or 0.11 tonnes per hectare. This information is used to estimate the extent of fuelwood extraction from the Puyankutty forest. The total annual loss of fuelwood due to the submergence of 2570 hectares of forest (i.e. 2800 hectares minus the agricultural area) would come to 287.7 tonnes. This is equivalent to a monetary loss of Rs.287700 (based on the assumption that the opportunity cost of labour involved in collection is near zero).

b) *Reed*: This is an important raw material used by the paper factories such as Hindustan Newprint Limited (HNL) and traditional weavers for making baskets, mats and so on. Collecting information from various sources, we arrive at 14000 MT per year as the estimated loss on this account, which is valued at the current market price. Then the present value of the future stream of loss is calculated for different discount rates.

c) *Honey*: The total potential loss is estimated to be 250 kg per annum, which is again valued at the market price and turns out to be Rs.25000 per annum.

d) *Medicinal plants:* Although the SACON study has given a list of the medicinal plants available in the area, no information on the rate of current extraction is available. We therefore apply a rule of thumb to arrive at a potential loss of Rs.10 lakhs (a rather high figure by any standard).

3) *Fishing and hunting:* No significant loss is anticipated since these activities are rarely seen in the area. The reservoir created as part of the project may even enhance the scope for fishing.

4) *Tourism*: The area is not currently visited by tourists. The project and the associated infrastructure may in fact facilitate forest and wildlife based tourism in the area. It may be noted that the most frequently visited forest and wildlife areas in Kerala are those surrounding dam projects. We ignore, however, both losses and gains on account of tourism.

5) *Erosion control and water retention*: In the case of a hydro-electric project the effect of soil erosion ends at the dam and it will be reflected in the reduced life span of the reservoir, or in the additional cost of catchment area treatment. Since we include the cost of catchment treatment in the direct costs and since there is adequate dead storage for the silt in the reservoir, we need not include any additional amount on the cost side. No loss needs to be recorded on account of water retention service too. For the storage of water in the reservoir, there will be no less water retention in the upstream part of the river basin.

6) *Carbon sequestration*: Destruction of a piece of forest can lead to this loss in two ways. First, a loss of sink in the form of a growing forest absorbing carbon annually, and second, return of the carbon back to atmosphere due to the complete destruction of

forest cover for the project (Brown and Pearce, 1994). If there is an annual growth of bio-mass in the erstwhile forest, which is being extracted and used in a way without releasing either part or full of its carbon content back to atmosphere, then it serves as a sink absorbing carbon every year. For valuation, we follow some global estimates usually done in a developed country context, which either focus on the abatement costs or the willingness to pay for the protection of tropical forests as their contribution to the control of global warming.

(a) Loss of flow of carbon intake per annum

Though Puyankutty is covered by a normal forest, it is subjected to reed extraction of about 5T per hectare per year, the biomass equivalent of which is 8T/ha per year. This is equivalent to a carbon intake of 8T/ha (based on the conversion factors given in Brown and Pearce, 1994). We can assume that carbon from 50% of the extracted reed goes back to the atmosphere, and thus the effective carbon intake per annum is only about 2T/ha. Then the net loss of carbon intake per annum is 2 x 2570 = 5140T. This is equivalent to a loss of 51400 US dollars (Rs. 2.21 crores) per annum based on the estimate by Brown and Pearce that 1 tonne of carbon emission leads to a loss of 10 dollars.

(b) Loss due to the release of carbon stock.

In this case, there can be at least two estimates. First one is based on the standing volume of timber in the Puyankutty forests. SACON study estimates that there is 17 lakh cu.m. of timber in the submergible area. This is equivalent to 227742.4 tonnes (with density 0.2/cu.m.), which is equivalent to a total biomass of 364387 tonnes or carbon content of 182193 tonnes. If we assume that all this carbon goes back to the atmosphere, which is quite unlikely, then the loss on this count comes to 1821930 US dollars.

The second estimate is based on the suggestions by Brown and Pearce (1994) that the destruction of 1 ha of forest will lead to the release of 283 tonnes of carbon back to atmosphere. There will be a reduction of this net release, if the land so cleared is used for or allowed to have biomass growth. However, in the case of a hydro-electric project, the land cleared will be covered with water and hence it is not available in future as a carbon sink. Thus one has to take the full value of 283 tonnes for the estimation. Hence the destruction and submergence of Puyankutty forest will release about 735800 tonnes of carbon and this is equivalent to a loss of 735800 US dollars (Rs. 31.63 crores). We have taken this value for the cost-benefit analysis.

7) *Nutrient retention*: This is also not a major issue in the case of a hydro-electric project because of water storage. Along the downstream of the river, no change in the level of nutrient retention is likely. The cost of catchment treatment should normally take care of the loss on account of changes in nutrient retention in the catchment area.

8) *Wild life habitat:* The SACON study noted that about 25 elephants live in the whole area, and that “no elephant corridor connecting Puyankutty with other forests will be lost in the case of construction of the proposed dam and reservoir formation”. However, it is noted that the signs of elephant movement were more visible in the submergible area. For the purpose of valuation, this needs to be considered separately from the biological diversity. The value of elephants might also be reflected in tourism and commercial use and may also have non-use values.

9) *Depository of biodiversity*: The environmental impact assessment done by SACON provides many useful insights on this issue. The study made an assessment of the flora and fauna of the whole Puyankutty area of 314 sq.km (of which about 30 sq.km or ten percent will be submerged or directly destroyed because of the project). 68 per cent of the submergible area of 2800 hectares sustains forests. It is composed of riverain, low lying evergreen and reed brakes. The number of plant species located in the study area (314 sq.km) is 326 of the following types: 132 trees; 139 herbs; 39 shrubs; 8 epiphytes, 6 climbers; and 2 liana. After taking into account the additional 200 species identified by other studies in this area, the total number of plant species comes to 526. Among them, five are endangered/ rare/vulnerable. Economically important species other than timber trees include medicinal plants, reed (Ochlandra sp), wild relatives of cultivated plants. Regarding fauna, the estimated numbers are: 32 species of butterflies and 289 species of vertebrates. Though there are plant and animal species endemic to Western Ghats, “no species of plants and animals recorded during the study was exclusively endemic to the Puyankutty forests” (SACON, 1999). However, 11 out of 16 species of birds endemic to Western Ghats are present in the whole Puyankutty area. Since this description of diversity refers to the whole Puyankutty area, is it obvious that the same characterisation applies to the area of submergence (which is only ten percent of the Puyankutty forest)? The study, however, did not report any unique feature of the forest area that will be submerged under the reservoir. Even if we accept the description of diversity as

characteristic of the submergible area, valuation of it remains a formidable task. The relevant value concept here is of 'option' kind. This is based on the idea that users will be willing to pay for the option of using the environment in the future even if they do not use it currently. This arises from uncertainty and the possibility that in the future the environment may be of value, even if it is not today. Potential use in pharmaceutical industry is a major source of option value. Since estimates of the value of biodiversity of this area are not available, we use data from similar areas in other parts of the world for making 'informed guess' on the quantitative extent of the loss on this account. A similar evergreen forest in Cameroon of 126262 ha is estimated to have a value of 500,000 British Pounds for its bio-diversity (Ruitenbeck, 1989). This is based on the potential for creating patents in pharmaceuticals. This comes to about 4 pounds per ha, and can be used to estimate the value of bio-diversity in Puyankutty area. Thus the value of 2500 ha turns out to be 10,000 pounds and hence a net worth of about Rs.7 lakhs.. Though the loss on account of bio-diversity will actually occur only with the 8th year of construction, its value is enhanced in the estimation by including it in the first year.

10) *Micro-climate stabilisation*: The Indian Forest Conservation Act, 1980 (as amended in October, 1992) makes the following suggestion on how to account for some of the ecological services (which includes micro-climatic balance) provided by the forest: "Though technical judgement would be primarily applied in determining the losses, as a thumb rule the environmental value of one hectare of fully stocked forest (density 1.0) would be taken as Rs.126.74 lakhs to accrue over a period of 50 years. The value will reduce with density." Since in our case the other components

of loss mentioned in the Act, such as soil erosion and water retention, are not important, we need to revise downward the thumb rule suggested above. We deliberately choose not to make the changes so that the estimates reflect the most pessimistic scenario.

We have so far discussed only use values of tropical forests, which include direct and indirect use values and option value. There is 'existence value' of the forest as well, which is what non-users are willing to pay for the preservation of the forest for its own sake, and is unrelated to current or future use. We discussed in Section 3 how we account for non-use values in the cost-benefit analysis of the project.

We now consider losses due to dislocation of human settlements, changes in ecological systems, and a few others.

4.1.3 Losses due to dislocation of human settlements

The project will lead to submergence of human settlement areas along with the forest. The social impact assessment study reported dislocation of about 115 tribal families and some non-tribal settlers (Santhakumar and Sivanadan, 1998). The study also provided the details of the cost of rehabilitation, which comes to about Rs.28.5 crores at 1998 prices. We simply use that estimate, after adjusting for price change.

4.1.4. Impact on other ecosystems

Besides the loss of forest, the dam and the reservoir can create harmful (and beneficial) effects on ecosystems, mainly the downstream riverain environment. Following Dixon, Talbot, and Le Moigne (1980), some of these effects and possible ways of valuing them are discussed here.

The quality of river water downstream is likely to change for several reasons. First of all there will be an increase in organic matter in the reservoir area and hence a deterioration of water quality. This increase in organic matter might change the flora and fauna along the downstream of the river. However, this can be taken as a temporary phenomenon which may disappear after a few operations of the reservoir. Secondly, water quality downstream also depends on water quantity. The construction of the reservoir will reduce the flood discharge and increase the summer discharge. Such changes can have beneficial as well as negative effects. For example, a number of chemical industrial units located along the downstream of Periyar currently face severe shortage of water for diluting their effluents during summer and cause industrial pollution. Thus the increased summer discharge that can flow from the reservoir will reduce this pollution and improve water quality downstream. However, the water quality changes associated with change in discharge might lead to some changes in the biotic environment, which had been adapted to flood discharges during monsoon and very lean flows in summer. Since flood flows do not lead to a significant increase in the depth of water flow for a longer time in Kerala (due to quicker discharge to the sea), it is more unlikely to develop a sustainable flood-dependent biotic environment in the river. Thus the impact on downstream flora and fauna that may occur due to the potential change in water discharge in the river does not seem to be significant. However, the blocking of water at dam site may deprive water supply to the stretch of riverside between the dam site and the point at which water from the power house reaches the river. There should be an additional cost of ensuring a minimum water flow in this region. This cost along with the benefits from improved water supply downstream should be taken into account in the cost-benefit analysis.

Reduction in silt load downstream would have more negative effects, if flood water was used directly for deltaic cultivation. That is not the case in Kerala. Flood water is not welcome to fields, since water levels in the fields during that period are already high due to rainfall. Therefore the absence of flood water will not much deprive the downstream of fertile soil deposits. Moreover, canal irrigation on the river is storage-cum-canal based, which already includes sediment removal, and hence the construction of one more dam does not significantly reduce the silt load in canals. Thus the issue of reduction of silt load downstream can be ignored. The change in water temperature also seems to be insignificant, since one cannot expect any sharp decrease in the temperature of the water stored in the reservoir. Moreover, the smaller reduction that would occur during storage would be nullified during the movement of water through shallow canals subject to normal temperature regimes.

There are potentially positive and negative effects on health of human beings and animals. Water stagnation and water-logging caused due to storage and canal irrigation might create diseases. Instances of canal-induced water-logging in Kerala, though not widespread, have been noted in some irrigation projects. Thus the expenditures to avoid water-logging and stagnant pools should be reduced from the irrigation benefits associated with projects. Benefits in terms of health are primarily associated with the increased water flow during summer, which in turn will reduce the degeneration of down stream water bodies. This will benefit the people, who depend on river for domestic water requirements and the sanitary water environment, by reducing incidence of water borne diseases downstream.

In the case of fishery, it seems that the beneficial effects dominate the negative ones. There is scope for developing reservoir-based fishery.

Loss of fishery in the down stream part of the river does not seem to be significant since flow of water is assured almost throughout the year. The possibility of recreation on the river will not be lost either since there is moderate flow throughout the year. In fact there are added opportunities for recreation in and around the new reservoir. This is evident from the fact that in Periyar National Park, formed around another reservoir, boating attracts about 200000 domestic and 15000 foreign visitors per annum. Even if such scale is not reached, the recreation benefits will be much more than the lost opportunities in this regard. The benefits due to moderation of flood discharge outweigh the costs due to reduced fertility, since the delta form of cultivation is not much prevalent in the downstream of Puyankutty or Periyar river. Regarding intrusion of salinity, it is evident from the engineering evaluation of the project, carried out by the Indian Institute of Science, that the water available for downstream release is more than adequate to meet the salinity requirements throughout the year. This has to be considered as a beneficial aspect of the project, given the current level of salinity intrusion in the Periyar basin.

Overall, it is reasonable to assume that the beneficial effects that have been discussed so far will dominate the losses. This is because the reservoir will reduce the silt load downstream and also increase water availability in the river during summer. For inadequate data we do not make any estimate of the beneficial or adverse effects. For other aspects such as chemical water quality, discharge variation and flood attenuation the project has very significant beneficial effects, and these are taken into account in the form of 'additional benefits'.

4.1.5. Cost of protection against Reservoir Induced Seismicity (RIS).

If the reservoir results in higher level of seismic activity, the increased cost of constructing earthquake resistant structures should be taken into account in the cost-benefit analysis. The engineering evaluation report prepared by the Indian Institute of Science notes that the proposed structure has the ability to withstand potential earthquakes in the area. However, 'given the complex nature of the seismic phenomena and the current state of knowledge on the subject of reservoir induced seismicity', the report suggests that KSEB take some precautionary measures. These include better seismic surveillance, strict adherence to the recent design standards for earthquake resistant structures, and the analysis of planned structures for their ability to withstand such dynamic forces. An amount of Rs.50 lakhs is estimated to be needed for having two more monitoring stations. In addition, the cost of the dam will increase by one percent if all the measures are taken. This is taken into account in the cost-benefit analysis.

4.1.6. Cost of controlling extensive deforestation

Hydro-electric projects such as Puyankutty can lead to destruction of forests beyond the area submerged by the reservoir. Construction of the project leads to opening up of, and increased accessibility to, previously not-so-accessible forest areas. The extent of such deforestation is influenced by a number of factors. They include development of roads and transport facilities in the project area, the state of forest protection in the region, likelihood of emergence and persistence of illegal settlements, management of settlements and labour colonies during the construction stage of the project, and so on. Increasing accessibility per se cannot be construed as a cause of deforestation, since improved accessibility through better roads can also facilitate better forest protection. For example, most of the forest roads in Puyankutty are underdeveloped and this makes the movement of forest staff difficult and costly. If better roads are available, forest staff may be able to reach interior locations quickly so as to handle destructive activities such as illegal logging or forest fires. Thus the possibility of extensive deforestation depends very much on the institutional and political environment of the state, and the capability of the monitoring agencies such as the forest department.

In order to examine the possibility of extensive deforestaion and feasible mechanisms to avoid such eventuality, we made a rapid assessment of some of the hydro-electric projects which are in operation in the state. Prolonged construction of the project, large assemblage of workers who stayed there during the long construction phase, development of township catering to this concentration of workers, workers' expectation of getting illegal or semi-legal ownership of land in the nearby locality which is made possible by the land settlement policies of the State are some of the factors that induced extensive deforestation in the specific case of a project implemented in the seventies. Some other projects, however, could avoid such consequences mainly because of timely completion.

The following mechanisms may be considered to avoid extensive deforestation: locating labour colonies away from the project (or forest areas) or allowing workers to project site only for work, fencing and guarding forests surrounding construction locations, more forest-guarding check-posts in the newly constructed roads, enhanced vigilance by the forest department during the period of construction, and possibly a higher-level supervisory body to oversee the above activities. Each of these will increase the project cost. For example, if workers were given shelter in non-forest areas, they would require regular transportation to the project site. Provision of kerosene or gas is needed to ensure that the workers do not depend on nearby forests for fuelwood. The cost on these counts can be estimated and added to the project cost. The additional forest-protection cost due to measures such as fencing, checkposts, and manning these facilities can also be estimated and incorporated into the cost-benefit analysis. An amount of Rs.15 lakhs per annum for this purpose is included in the analysis. The second part of the cost is that for transporting labour every day from an inhabited area and for providing non-wood fuel for the labour. The project envisages the use of about 2 crore mandays and an amount of Rs.20 crores (@Rs.10 per manday) is estimated to be required for these purposes.

4.2. The direct and indirect benefits of the project

4.2.1. The main benefit of the Puyankutty project is obviously power generation. However the benefit of power production is much more than the monetary income realised by KSEB through a state-determined or administrative tariff rate. One way of capturing the larger social benefit of power production is to assess the cost of production of power generation by the next available alternative method. In Kerala, the alternative to hydroelectricity seems to be thermal power. The cost of production of a unit of thermal power in 1997 was around 3 rupees. We have taken per-unit cost of thermal power as the reference point for estimating the social benefit of power production by the proposed project. Instead of taking any particular value, the benefit is calculated for a range of unit costs of thermal power, varying from Rs.3.0 to 4.5.

4.2.2. Besides power generation, there are other benefits which have to be estimated and included in the cost-benefit analysis. These include construction of a bridge and roads in the project area, and creation of more runoff in the river during the summer months. KSEB proposes to construct a bridge at Thattekkad, where presently a ferry takes the vehicles across the river. The cost of the bridge is estimated approximately at Rs.10 crores (@ 1996 prices). The people living in Kuttampuzha and nearby localities demand construction of this bridge. Therefore it is necessary to estimate the benefit of this bridge. One possibility is to estimate the number of vehicles, and the people currently using the ferry, and the total cost of operation which would include the payments for ferry service and the money equivalent of their waiting time. The data on the annual average number of vehicles using the ferry service have been collected from the ferry contractors. It is through this ferry that most of the 17000 MT of reeds collected from Puyankutty is transported to the Hindustan Newsprint Factory. Thus the benefits from the bridge are too important to be ignored.

4.2.3. It is also planned to construct or develop a number of roads leading to the project area for the smooth implementation of the project. Most of these roads pass through areas of habitation and therefore directly benefit people.

4.2.4. As mentioned earlier, the summer runoff from the reservoir will be directly beneficial to the irrigation projects in the downstream (as Periyar valley project will have more water to divert through its Right Bank Canal), to the industries situated in the lower reaches of Periyar river, and to people of towns and villages situated along the down stream, up to the coastal area.

The indirect benefits listed above are calculated by apportioning a part of the cost of providing the required structures and reducing it from the cost of the power project. Thus an amount of Rs.11 crores is taken to be that part of the cost of roads and bridges from which the benefits are derived by the activities outside the scope of the electricity project. Rs.6.5 crores per annum for a period of six years is taken as the expenditure for providing irrigation services. These apportioned costs are reduced from the cost of the power project.

4.3. The cost-benefit analysis and its implications

In 4.1 and 4.2 all the costs and benefits have been identified and estimated. On the benefit side, besides electricity other direct and indirect benefits were also listed. The benefits and costs are now put together in order to carry out the cost-benefit analysis. We first consider only the direct benefits from power production and examine if the net benefit is positive or not. We then broaden the set of benefits and do the same exercise.

As mentioned earlier, benefits of hydroelectricity are valued in terms of its alternative, i.e. thermal power. Since the environmental losses of Puyankutty project are taken into account for the cost-benefit analysis, it is necessary to consider the potential environmental cost of alternative energy. It is well-known that thermal projects are not environmentally very clean. However, a proper assessment of the environmental costs of thermal projects is beyond the scope of this exercise. It is therefore reasonable to assume that the environmental pollution created by thermal projects will make its social cost higher than their accounting cost. (For example, if 3 rupees is the accounting cost of one unit of thermal power, a higher cost of 3.25 or 3.5 can be taken as its social cost.) Thus the sensitivity analysis with different values of the unit cost of alternative will throw some light on the question of feasibility of hydroelectric energy.

The calculation of net benefit has been subjected to a sensitivity analysis by changing the discount rate from 2 to 12 percent. Such sensitivity analysis precludes the need for any ad hoc selection of discount rates by the analyst and enables us to leave the choice of appropriate discount rate to the planners and to other decision-makers. An alternative suggested by Markandya and Pearce (1994) is that the sustainability issue can better be taken care of by making provisions for compensatory projects. The idea is to ensure that the stock of natural capital is not reduced. This alternative has also been tried here. The planners of the Puyankutty project have already proposed a compensatory afforestation project. Though a cultivated forest cannot substitute a natural one in all aspects (especially in terms of biodiversity), it can serve most of the functions considered earlier for valuation, after attaining a stage of maturity. We have therefore also compared the estimated losses due to deforestation with that of compensatory afforestation.

In this analysis, an attempt is also made to understand the influence of non-use values. Hypothetical figures for non-use values are generated, which, if quoted by households in Kerala as the amount they would attribute to non-use values, would yield zero net benefit for the project (under different discount rates). This, we believe, would partially take care of the problems in capturing non-use values which any environmental valuation exercise must confront.

4.3.1. Feasibility on considering only the power benefits

The present value of all the costs on account of the project is presented in Table 1. The total cost (its present value) is deducted from the benefit of power for different unit costs of alternative energy and presented in Table 2. Based on these tables, the present values of the net benefits of power production (i.e., total benefits of power production minus direct costs and environmental losses) under different discount rates and under different values of the cost of alternative energy are plotted in Figure 2. It is evident that net benefit becomes negative when the discount rate is 12 percent. Net benefit becomes negative even at 10 percent discount rate if the unit cost of alternative energy is less than Rs.3.50 The project produces positive net benefits under current market rate of interest (around 10%). This is so for the whole range of plausible values of the (social) cost of alternative energy.

The net benefit of the project increases somewhat sharply as we reduce the discount rate from 10 to 2 percent. It shows that a hydroelectric project such as this becomes more attractive if the discount rate is reduced due to environmental considerations. This confirms the apprehensions of the economists that the reduction of discount rate may not be an appropriate tool for incorporating sustainability or environmental considerations in the decision making.

It would be interesting to see if the project produces net positive benefits irrespective of the damages caused by it through submergence of the forest. KSEB has estimated different areas of submergence that would be required for different levels of power production. This is analysed in Figure 3, where the net benefit from power of the same project is plotted against different hypothetical values of the area of submergence. It is evident from the figure that the net benefit becomes close to zero as the area of submergence comes close to 5250 hectares. It shows that the feasibility of the project is not independent of the area of submergence. It is also clear that the issue of social trade-off between hydro-power and forest destruction has to be examined separately in each given context.

Figures 2 and 3 reflect inclusion of only the direct use values and option values of the environment. The potential impact of non-use values can be seen in Figure 4. It shows that if each and every household of Kerala quotes an average of 250 rupees as the non-use value of 2800 ha of the Puyankutty project, then the project should be abandoned (under 10 percent discount rate and Rs.4.0 as the cost of alternative energy). This value goes up as discount rate decreases. For example the value goes up to Rs.6500 if the discount rate is only 2 percent. It gives some idea about the non-use values required to reject the project and opt for conservation.

So far we have considered only the benefits from power production. However as discussed earlier the project also creates benefits through infrastructure, irrigation and water management. When these benefits are included in the analysis, the feasibility status of the project is slightly altered and it is discussed in the following section.

Figure 2: Net benefits Vs Cost of alternative energy (without considering the benefits other than power)

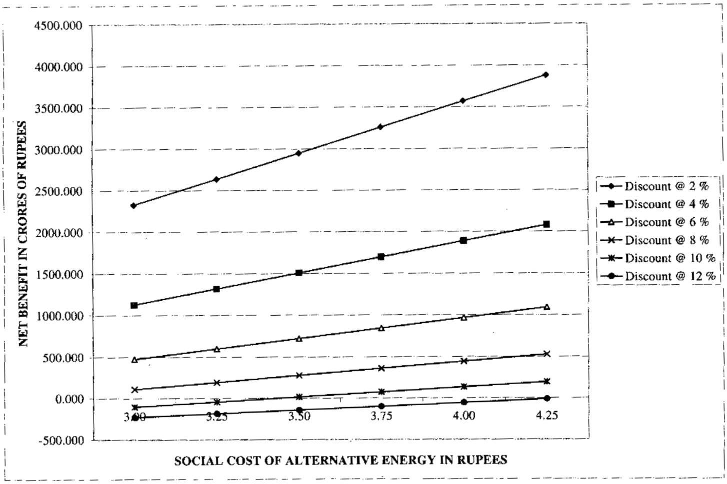


Figure 3 : Net Benefits Vs Loss of Forest Area (without considering benefits other than power)

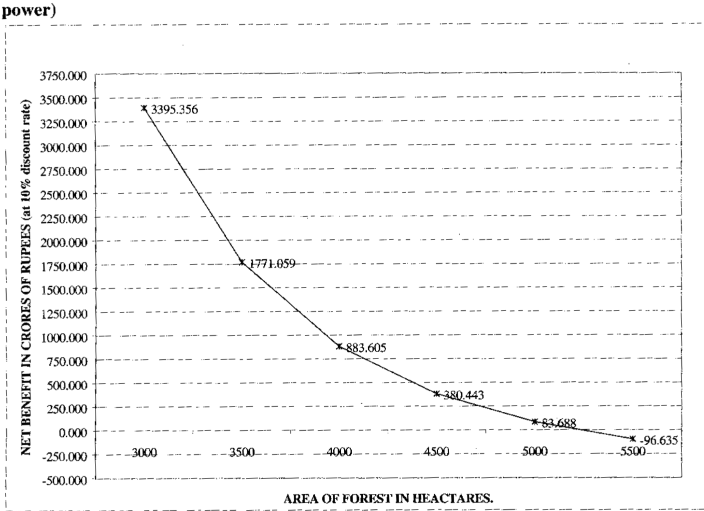
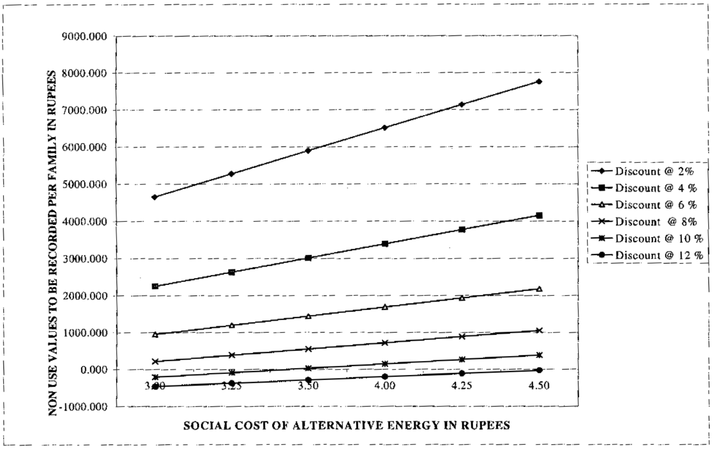


Figure 4: Non use values to be Quoted by Each of 50 Lakhs Kerala Households to Reject the Project (without considering benefits other than power)



21

4.3.2. Feasibility with all the benefits

The additional benefits from infrastructure and irrigation are accounted for by reducing the apportioned cost of such services from the total cost of the power project. This adjusted total cost is derived from Table 3, and is reduced from power benefits in Table 4. The pattern of net benefits from this analysis can be seen in Figure 5. It shows that the project produces net positive benefits even at the discount rate of 12 percent when the social cost of alternative energy is around Rs. 4.25/ unit. Obviously it produces positive benefits under all other discount rates and under a realistic regime of the opportunity cost of energy.

As evident from Figure 6 the project would become economically infeasible if it resulted in a submergence of about 5400 hectares of forest. The non-use value required to reject the project under this condition goes up to Rs.400 per household of Kerala (with 10 percent discount rate and 4 rupees as the opportunity cost of energy).

Figure 5: Net Benefits Vs Cost of Alternative Energy (with all the benefits)

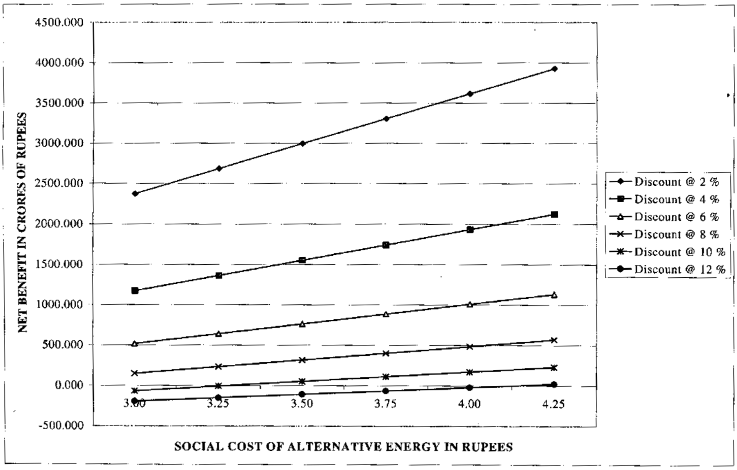
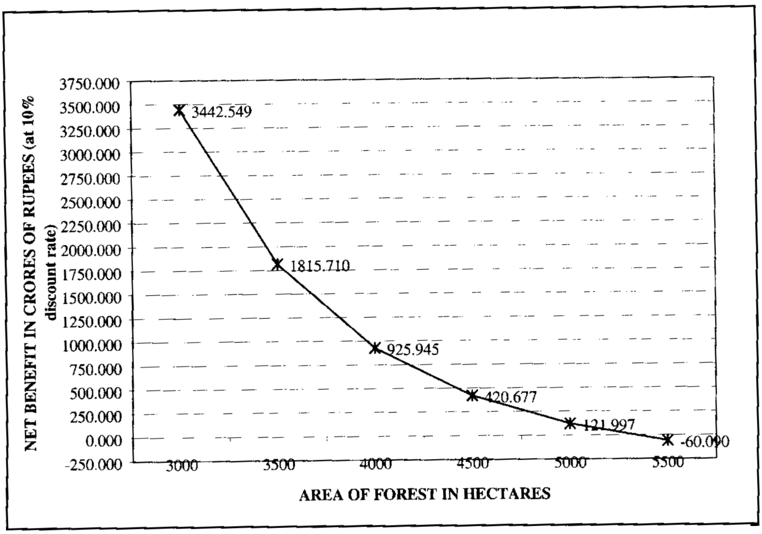


Figure 6: Net Benefits Vs Loss of Forest Area (with all the benefits)



In sum, the net benefit of the project is positive if the social cost of alternative energy is more than 4.00 rupees per unit. The conclusion on the feasibility of the project (which is of contingent nature, since the social cost of its alternative is yet to be ascertained), is based not only on the consideration of use values of environmental resources but also their non-use values. The non-use value required to reject the project (or to make its net benefit equal to zero) at this level is about Rs.100 crores, which seems to be a rather high figure given the fact that most of the environmental functions have already been taken into account under the use-value.

In the cost benefit analysis, an amount of Rs.32 crores is accounted for rehabilitating the tribal families and for compensating the settler agriculturists. Though the decision rule in the cost-benefit analysis only requires generation of benefits to *potentially* compensate such losers, we feel that the valuation of these losses itself is based on some assumptions of fair and efficient compensation. In the event of failure on the part of the implementing agency to achieve this efficient and timely compensation, the loss on account of consequent human sufferings is much more than what has been estimated in the analysis. Thus it is important to ensure fair, efficient and timely compensation, in the event of implementing the project.

4.3.3 Comparison of forest losses with the compensatory project

As mentioned earlier the planners of the Puyankutty project accounted for a compensatory afforestation project at an expenditure of Rs.32 crores (@1994 prices), which is Rs.55 crores at current prices. This compensatory project envisaged afforestation of an area equal to the one used for the project. It is well known that such afforested area will not be able to substitute completely the natural forest destroyed for the project, in terms of all the tangible and intangible resources. The cost-benefit analysis shows that the total loss on account of the destruction of the forest comes to around Rs.63 crores. This includes losses on account of foregone goods such as reed, fuel wood, honey and so on, future options of using diverse plants and wild genes, and environmental services such as carbon sequestration. The compensatory project, if implemented properly, would be sufficient to compensate most of the goods and services provided by the natural forests in the long run except for bio-diversity. This is based on the information that the forest that will be destroyed by the Puyankutty project does not have any unique characteristic (as noted by the SACON study).

Though the environmental cost-benefit analysis carried out here has by and large accounted for most of the losses due to forest destruction, it is felt that a serious consideration for the compensatory project would make possible incorporation of the sustainability criteria (the need to keep the stock of natural capital undiminished) in the project.

5. Conclusion

The paper has followed a step-by-step approach to show (1) how valuation of the environmental impact of a hydroelectric project can be done in practice, and (2) how this can be incorporated into the cost-benefit analysis of the project. As most of the development projects have their impact on the environment, any cost-benefit analysis that ignores these impacts must be erroneous. The difficulties involved in valuing the environment have sometimes led to the view that projects with any negative environmental consequences must not be taken up. This view essentially ignores the possibility of a trade-off that the society would like to make while taking an action. It is evident from the approach followed here that the cost-benefit analysis can be used as a powerful tool to facilitate decision making at the societal level. Instead of deriving an ‘accept-reject’ kind of conclusion, we present a range of alternative scenario so that the decision maker has the flexibility to choose the most desirable course of action.

Table 1. Different Costs and their Present Values (without considering benefits other then power)

No.	IDEN	COST	T1	T2	PV1	PV2	PV3	PV4	PV5	PV6
1	DIRECT COST-1st YEAR	38.0710	0	0	38.071	38.071	38.071	38.071	38.071	38.071
1	DIRECT COST-2nd YEAR	45.6850	1	1	44.789	43.928	43.099	42.301	41.532	40.790
1	DIRECT COST-3rd YEAR	144.6720	2	2	139.054	133.757	128.758	124.033	119.564	115.330
1	DIRECT COST-4th YEAR	163.7070	3	3	154.265	145.535	137.452	129.956	122.995	116.520
1	DIRECT COST-5th YEAR	186.5500	4	4	172.343	159.464	147.765	137.120	127.416	118.560
1	DIRECT COST-6th YEAR	137.0570	5	5	124.137	112.651	102.417	93.279	85.102	77.770
1	DIRECT COST-7th YEAR	106.6000	6	6	94.658	84.248	75.149	67.176	60.173	54.007
1	DIRECT COST-8th YEAR	83.7590	7	7	72.917	63.650	55.705	48.873	42.982	37.888
1	DIRECT COST-9th YEAR	45.6850	8	8	38.992	33.382	28.663	24.682	21.312	18.451
1	O & M Cost	9.5186	9	50	229.380	140.394	90.922	61.746	43.594	31.762
2	REHABILATION COST	33.5830	1	1	32.925	32.291	31.682	31.095	30.530	29.985
3	TIMBER	0.0000			0.000	0.000	0.000	0.000	0.000	0.000
4	REED	2.7080	1	50	85.095	58.174	42.683	33.128	26.849	22.489
5	FUEL FOOD	0.0300	1	50	0.943	0.644	0.473	0.367	0.297	0.249
6	HONEY	0.0030	1	50	0.094	0.064	0.047	0.037	0.030	0.025
7	ENVIRONMET LOSSES-1	2.1300	9	50	51.329	31.416	20.346	13.817	9.755	7.108
8	BIODIVERSITY LOSS	0.0700	1	1	0.069	0.067	0.066	0.065	0.064	0.063
9	CARB SEQ.LOSS-STOCK	32.0000	8	8	27.312	23.382	20.077	17.289	14.928	12.924
10	CARBON SEQ.LOSS/YR.	2.2610	8	50	56.416	35.001	23.016	15.888	11.410	8.458
11	NUTRIENT RETENTION	0.0000			0.000	0.000	0.000	0.000	0.000	0.000
12	MEDICINAL PLANTS	0.1000	1	1	0.098	0.096	0.094	0.093	0.091	0.089
13	DOWNSTREAM ENV.LOSS	0.0000			0.000	0.000	0.000	0.000	0.000	0.000
14	FOREST PROTECT. COST	0.1500	1	50	4.714	3.222	2.364	1.835	1.487	1.246
15	MONIT. COST FOR RIS	0.5000	0	0	0.500	0.500	0.500	0.500	0.500	0.500
16	ADDL.COST OF DAM DUE TO RIS	9.5200	0	0	9.520	9.520	9.520	9.520	9.520	9.520
17	FUEL C OST FOR LABOUR	2.1000	0	9	19.241	2.100	2.100	2.100	2.100	2.100

PV1 – Present value at discount rate 2 %
PV2 – Present value at discount rate 4 %
PV3 – Present value at discount rate 6 %
PV4 – Present value at discount rate 8 %
PV5 – Present value at discount rate 10 %
PV6 – Present value at discount rate 12 %
T1 – Starting period of spending cost
T2 – Closing period of spending cost

Table 2. Estimate of Benefits from Power and Net Benefits

IDEN	PV @ 0.02	PV @ 0.04	PV @ 0.06	PV @ 0.08	PV@ 0.10	PV @ 0.12
Present Value of Total Cost	-1396.862	-1151.557	-1000.969	-892.971	-810.302	-743.905
Present Value of Power Estimate @ 3 Rs/unit	3724.606	2279.673	1476.367	1002.607	707.868	515.745
Net Estimate @ 3 Rs/Unit	2327.744	1128.116	475.398	109.636	-102.434	-228.160
Present Value of Power Estimate @ 3.25 Rs/unit	4034.990	2469.646	1599.398	1086.157	766.856	558.724
Net Estimate @ 3.25 Rs/Unit	2638.128	1318.089	598.429	193.186	-43.446	-185.181
Present Value of Power Estimate @ 3.50 Rs/unit	4345.374	2659.619	1722.429	1169.708	825.845	601.702
Net Estimate @ 3.50 Rs/Unit	2948.512	1508.062	721.460	276.737	15.543	-142.203
Present Value of Power Estimate @ 3.75 Rs/unit	4655.758	2849.592	1845.459	1253.259	884.834	644.681
Net Estimate @ 3.75 Rs/Unit	3258.896	1698.035	844.490	360.288	74.532	-99.224
Present Value of Power Estimate @ 4.00 Rs/unit	4966.141	3039.565	1968.490	1336.809	943.823	687.660
Net Estimate @ 4.00 Rs/Unit	3569.279	1888.008	967.521	443.838	133.521	-56.245
Present Value of Power Estimate @ 4.25 Rs/unit	5276.525	3229.537	2091.521	1420.360	1002.812	730.639
Net Estimate @ 4.25 Rs/Unit	3879.663	2077.980	1090.552	527.389	192.510	-13.266

Table 3. Different Costs and their Present Values (with all the benefits)

No.	IDEN	COST/BENEFIT	T1	T2	PV1	PV2	PV3	PV4	PV5	PV6
1	DIRECT COST-1st YEAR	38.0710	0	0	38.071	38.071	38.071	38.071	38.071	38.071
1	DIRECT COST-2nd YEAR	45.6850	1	1	44.789	43.928	43.099	42.301	41.532	40.790
1	DIRECT COST-3rd YEAR	144.6720	2	2	139.054	133.757	128.758	124.033	119.564	115.330
1	DIRECT COST-4th YEAR	163.7070	3	3	154.265	145.535	137.452	129.956	122.995	116.520
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2	REHABILATION COST	33.5830	1	1	32.925	32.291	31.682	31.095	30.530	29.985
3	TIMBER	0.0000			0.000	0.000	0.000	0.000	0.000	0.000
4	REED	2.7080	1	50	85.095	58.174	42.683	33.128	26.849	22.489
5	FUEL FOOD	0.0300	1	50	0.943	0.644	0.473	0.367	0.297	0.249
6	HONEY	0.0030	1	50	0.094	0.064	0.047	0.037	0.030	0.025
7	ENVIRONMET LOSSES-1	2.1300	9	50	51.329	31.416	20.346	13.817	9.755	7.108
8	BIODIVERSITY LOSS	0.0700	1	1	0.069	0.067	0.066	0.065	0.064	0.063
9	CARB SEQ.LOSS-STOCK	32.0000	8	8	27.312	23.382	20.077	17.289	14.928	12.924
10	CARBON SEQ.LOSS/YR.	2.2610	8	50	56.416	35.001	23.016	15.888	11.410	8.458
11	NUTRIENT RETENTION	0.0000			0.000	0.000	0.000	0.000	0.000	0.000
12	MEDICINAL PLANTS	0.1000	1	1	0.098	0.096	0.094	0.093	0.091	0.089
13	DOWNSTREAM ENV.LOSS	0.0000			0.000	0.000	0.000	0.000	0.000	0.000
14	FOREST PROTECT. COST	0.1500	1	50	4.714	3.222	2.364	1.835	1.487	1.246
15	MONIT. COST FOR RIS	0.5000	0	0	0.500	0.500	0.500	0.500	0.500	0.500
16	ADDL.COST OF DAM DUE TO RIS	9.5200	0	0	9.520	9.520	9.520	9.520	9.520	9.520
17	FUEL COST FOR LABOUR	2.1000	0	9	19.241	2.100	2.100	2.100	2.100	2.100
18	ADDIT. BENE FROM ROAD&BRIDGE	11.0000	1	1	10.784	10.577	10.377	10.185	10.000	9.821
19	ADDIT. BENE FROM IRRIGATION	6.5000	1	6	36.409	34.074	31.963	30.049	28.309	26.724

PV1 – Present value at discount rate 2 %
PV2 – Present value at discount rate 4 %
PV3 – Present value at discount rate 6 %
PV4 – Present value at discount rate 8 %
PV5 – Present value at discount rate 10 %
PV6 – Present value at discount rate 12 %
T1 – Starting period of spending cost
T2 – Closing period of spending cost

Table 4. Estimate of Power and Other Benefits, and Net Benefits

IDEN	PV @ 0.02	PV @ 0.04	PV @ 0.06	PV @ 0.08	PV@ 0.10	PV @ 0.12
Present Value of Total Cost	-1349.669	-1106.906	-958.629	-852.737	-771.993	-707.360
Present Value of Power Estimate @ 3 Rs/unit	3724.606	2279.673	1476.367	1002.607	707.868	515.745
Net Estimate @ 3 Rs/Unit	2374.937	1172.767	517.738	149.870	-64.125	-191.615
Present Value of Power Estimate @ 3.25 Rs/unit	4034.990	2469.646	1599.398	1086.157	766.856	558.724
Net Estimate @ 3.25 Rs/Unit	2685.321	1362.740	640.769	233.420	-5.137	-148.636
Present Value of Power Estimate @ 3.50 Rs/unit	4345.374	2659.619	1722.429	1169.708	825.845	601.702
Net Estimate @ 3.50 Rs/Unit	2995.705	1552.713	763.800	316.971	53.852	-105.658
Present Value of Power Estimate @ 3.75 Rs/unit	4655.758	2849.592	1845.459	1253.259	884.834	644.681
Net Estimate @ 3.75 Rs/Unit	3306.089	1742.686	886.830	400.522	112.841	-62.679
Present Value of Power Estimate @ 4.00 Rs/unit	4966.141	3039.565	1968.490	1336.809	943.823	687.660
Net Estimate @ 4.00 Rs/Unit	3616.472	1932.659	1009.861	484.072	171.830	-19.700
Present Value of Power Estimate @ 4.25 Rs/unit	5276.525	3229.537	2091.521	1420.360	1002.812	730.639
Net Estimate @ 4.25 Rs/Unit	3926.856	2122.631	1132.892	567.623	230.819	23.279

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